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(71) Applicant : **SEAGATE TECHNOLOGY INTERNATIONAL**
c/o Maples & Calder
P.O. Box 309
Georgetown Grand Cayman Island (KY)

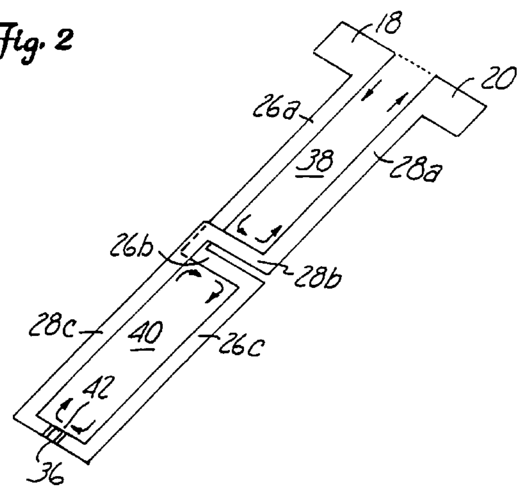
(72) Inventor : **Mowry, Gregory S.**
18 Geneva Boulevard
Burnsville, Minnesota 55306 (US)

(74) Representative : **Sturt, Clifford Mark et al**
J. MILLER & CO.
34 Bedford Row
Holborn
London WC1R 4JH (GB)

(54) Contact scheme for minimizing inductive pickup in magnetoresistive read heads.

(57) A disc drive recording head which senses magnetic flux from a storage medium includes an MR sensor positioned on a trailing surface of a disc drive slider. First and second electrical contacts connect the MR sensor to first and second pads positioned on the trailing surface of the MR slider and minimizes an inductive voltage induced from the storage medium during the sensing of the magnetic flux.

Fig. 2



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Jouve, 18, rue Saint-Denis, 75001 PARIS

The present invention relates to a contact configuration for connecting a magnetoresistive sensor for sensing magnetic flux from a storage medium to further circuitry, and a storage medium read head including the same.

Magnetoresistive (MR) sensors are used in magnetic storage systems to detect magnetically encoded information. A time dependent magnetic field from a magnetic storage medium or disc directly modulates the resistivity of the MR sensor. The change in resistance of the MR sensor can be detected by passing a sense current through the MR sensor and measuring the voltage across the MR sensor. The resulting signal can be used to recover information from a magnetic storage medium or disc.

Practical MR sensors are typically formed using ferromagnetic metal alloys because of their high magnetic permeability. A ferromagnetic metal alloy is deposited in a thin film upon an electrically insulated substrate or wafer. Changing magnetic fields originating from the magnetic storage medium produce a change in the magnetization direction of the MR sensor and thereby change the resistance of the sensor. This phenomenon is called an MR effect.

MR sensors have a maximum signal-to-noise ratio when the active region of the sensor has no movable magnetic domain boundaries or no domain boundaries. In other words, the active sense area of the MR sensor should be a single domain. The presence of domain boundaries in the sensor active area that move when a field is applied gives rise to Barkhausen noise, a phenomenon caused by the irreversible motion of a magnetic domain in the presence of an applied magnetic field. Barkhausen noise cannot occur if no domain boundaries exist. Typically, a single magnetic domain MR sensor is achieved by either utilizing geometry, or via boundary control stabilization or inherent longitudinal magnetic fields or any combination thereof.

During a read operation, an MR sensor transduces the data field of a medium directly by virtue of an MR effect and produces an MR voltage signal. However, the MR sensor also couples an ideally 90° out of phase voltage signal due to the inductive pickup from the contact loop configuration of the sensor current path providing current to the MR sensor (neglecting capacitance). The out of phase signal is undesired because it adds a coherent signal that is phase shifted away from the real MR signal attempting to be detected through use of the MR effect. Therefore, the MR sensor is detecting two different signals from a single medium. First, the MR sensor detects the MR signal representing the magnetic field directly. Second, the extended MR sensor contact structure detects the inductive pick-up signal from the time rate of change of magnetic flux of the medium linking by the single-loop contact configuration of the current path. The purpose of the MR sensor is to detect the MR signal representative of the magnetic field of the medium directly, and not the inductive pick-up signal from the time rate of change of the magnetic flux.

Inductive voltage signal detection is not normally associated with MR sensor operations due to the fact that most applications utilizing MR sensors have a relatively low disc velocity. The single-loop contact configuration of a conventional MR sensor current path (wherein the single loop is encompassed by the MR sensor, bond pads, and the electrical contacts connection the MR sensor to the bond pads) will not produce significant inductive time rate of change signals from a disc since its inductive output is directly proportional to disc velocity, which itself is relatively small.

In MR sensor operations having a relatively small head disc velocity, the inductive pickup signal induced by the single-loop contact configuration of a conventional MR sensor current path is often more than 40 db down in magnitude from the MR signal itself. As a result, induced noise does not substantially affect the MR signal due to its relatively small magnitude as compared to the MR signal. However, as a relative head disc velocity increases, the inductive pick-up signal transduced by the single-loop contact configuration of the MR sensor current path can be only 10-20 db in magnitude below the MR signal. This induced signal can represent a serious signal-to-noise ratio problem.

In high performance disc drive applications having large relative head disc velocity, the single loop contact configuration of a conventional MR sensor can transduce an inductive pick-up signal which is 90° out of phase with a desired MR signal and with a magnitude that causes error by peak shifting the information away from the desired timing windows of the information channel. The inductive pick-up signal results in head disc channel performance errors.

Thus, there is a need for a disc drive head for reading an MR voltage signal representing the magnetic flux from a magnetic storage medium directly while minimizing any induced inductive pick-up signal representing time rate of change of magnetic flux from the medium.

U.S. Patent Nos. 4,860,138 and 4,922,360 describe various read/write head designs.

According to one aspect of the present invention, there is provided an electrical contact configuration for connecting a magnetoresistive sensor for sensing magnetic flux from a storage medium to further circuitry, the contact configuration having first and second electrically conductive paths from said magnetoresistive sensor to the further circuitry, characterised in that the conductive paths are arranged such that they reduce the effect of an inductive pick-up signal occurring due to the storage medium on the electrical signal applied to said further circuitry via the electrically conductive paths and said magnetoresistive sensor.

According to another aspect of the present invention, there is provided a storage medium read head including an electrical contact configuration as defined above.

The disc drive head may directly sense magnetic flux from a magnetic storage medium through use of a magnetoresistive (MR) effect and produces a voltage signal (an MR signal) representing data from the storage medium. An electrical contact path connects an MR sensor to external circuitry during the sensing of magnetic flux from a storage medium. The electrical contact path may include a first electrical contact connecting the MR sensor to the first pad and a second electrical contact electrically connecting the MR sensor to the second pad. The first electrical contact may overlap the second electrical contact for a substantial distance between the MR sensor and the first and second pads. A single loop may be formed directly above the MR sensor having a small cross-sectional area, thereby minimizing inductive signals induced in the single loop during the reading of data from a storage medium. Preferably, the first electrical contact is positioned on a first metalization layer, while the second electrical contact has a first portion positioned on the first metalization layer and a second portion positioned on a second metalization layer, wherein the first and second metalization layers are electrically isolated from each other by an insulating layer.

Also, an electrical contact defining a plurality of loops may electrically connect the MR sensor to external circuitry. The time changing flux coupled into the loops may minimize an inductive voltage signal from the storage medium during the direct sensing of the magnetic flux. In one form the plurality of loops, which is defined by the electrical contacts, comprises a pair of oppositely oriented loops so that a first portion of the inductive voltage signal transduced by a first loop of the pair of oppositely orientated loops and is substantially equal in magnitude and opposite in polarity to a second portion of the inductive voltage signal transduced in a second loop of the pair of oppositely orientated loops. In another form, three loops are employed with the voltage signal induced in the first and second loops are equal in magnitude and opposite in polarity to the voltage signal induced in the third loop. Therefore, the inductive voltage signal induced from the storage medium during the direct sensing of the magnetic flux may be minimized.

The invention may be particularly suitable for high frequency, high data rate and/or high relative storage medium to read head velocity applications. The magnetoresistive disc drive head may have the capability of separating direct magnetic field effects and an inductive time rate of change effect resulting from a magnetic field and cancelling the undesired inductive time rate of change effect.

For a better understanding of the invention, embodiments will now be described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view of a disc drive slider showing the rear of the slider including a pair of the head configurations.

Figure 2 is a diagrammatic view of a first embodiment of the present invention using two loops.

Figure 3 is an exploded perspective view of the head elements of the first embodiment of the present invention.

Figure 4 is a greatly enlarged elevational view of the head portion of Figure 1.

Figure 5 is a diagrammatic view of an alternative embodiment of the present invention.

Figure 6 is a greatly enlarged elevational view of the head portion of the alternative embodiment shown in Figure 5.

Figure 7 is a diagrammatic view of a second alternative embodiment of the present invention.

Figure 8 is a diagrammatic view of a third alternative embodiment of the present invention.

Figure 9 is a diagrammatic view of a fourth alternative embodiment of the present invention.

Figure 10 is a side elevational view of the fourth alternative embodiment of the present invention shown in Figure 9.

Figure 1 is a view in perspective of disc drive slider 10 showing the rear of slider 10, incorporating an embodiment of the present invention, positioned above disc 35, which is a magnetic storage medium. Slider 10 includes head 12, rear surface 14, rails 16, pads 18, 20, 22 and 24, contacts 26, 28, 30 and 32, and recessed area 34. Rails 16 extend from rear surface 14 of slider 10 to the front surface of slider 10 (not shown in Figure 1). Rails 16 form recessed area 34 between the rails. Pads 18, 20, 22 and 24 provide electrical connections to circuitry (not shown) exterior to slider 10 .

Contacts 26, 28, 30 and 32 provide electrical connection to a pair of magnetoresistive (MR) sensors (not shown in Figure 1) at the bottom surface of rail 16 on rear surface 14. Contacts 26, 28, 30 and 32, also known as electrical leads or electrical contacts, are formed from a high conductivity metal to ensure a proper electrical connection. Contacts 26 and 28, as well as contacts 30 and 32, are routed as close together as possible, consistent with sense current carrying capabilities and photolithography constraints. In the past, contacts 26, 28, 30 and 32 were positioned parallel to one another vertically between pads 18, 20, 22 and 24 and the bottom surface of rails 16 at rear surface 14. The electrical circuit between contacts 26 and 28 was completed by an MR sensor located between the two contacts at the bottom surface of rail 16 at rear surface 14, thereby forming a first single loop contact configuration. Likewise, the electrical circuit between contacts 30 and 32 was completed by an MR sensor located between the two contacts at the bottom surface of rail 16 at rear surface 14, thereby forming a second single loop contact configuration.

Figure 2 is a greatly enlarged diagrammatic view showing a first embodiment of the present invention. The contact routing scheme in Figure 2 includes pads 18 and 20, contacts 26 and 28, MR sensor 36, cross-sectional areas 38 and 40, and MR sensor gap 42. Since the circuitry on the right half of slider 10, as shown in Figure 1, is identical to the circuitry on the left half of slider 10, only the circuitry on the left half of slider 10 is shown in Figure 2 for purposes of clarity. As shown in Figure 2, contact 26 includes contact portions 26a, 26b and 26c and contact 28 includes contact portions 28a, 28b and 28c. When connected to pads 18 and 20, contacts 26 and 28 form a three-dimensional figure-eight configuration. All cross over portions of contacts 26 and 28 are electrically isolated from each other by an insulating layer to prevent the possibility of shorting.

During a high-performance read application, magnetic flux radiates from disc 35 (shown in Figure 1) located directly beneath MR sensor 36 in a generally perpendicular direction from disc 35. Thus, most of the magnetic flux coming from the disc radiates generally perpendicular to disc 35 through MR sensor 36 between contacts 26 and 28.

MR sensor 36 is a ferromagnetic material used in a magnetic storage system to detect magnetically encoded information from disc 35 passing directly beneath MR sensor 36. A change in the magnetic field radiating from disc 35 modulates the resistivity of MR sensor 36. The changing resistance is detected by passing a sense current from pad 18 to contact 26, MR sensor 36, and returning to pad 20 via contact 28. The resulting voltage measured across MR sensor 36 can be used to recover information or data from disc 35.

In the present configuration, disc drive head 12 is detecting two distinct signals from disc 35. First, MR sensor 36 is detecting an MR signal representing the magnetic flux directly by virtue of an MR effect. An MR effect is the ability to fundamentally vary the resistivity of a ferromagnetic material as a function of an applied field, such as magnetic flux, to the magnetic material. Second, disc drive head 12 of Figure 1 is detecting an inductive pickup signal by virtue of the time rate of change of magnetic flux from disc 35 linking areas 38 and 40 bound by contacts 26 and 28 of Figure 2. An inductive effect is the ability to measure voltage as a function of the change in an applied field, such as magnetic flux, times a given area divided by a change in time (i.e. a time rate change of the applied field). The magnitude of the inductive pick-up signal is directly proportional to the time rate of change of magnetic flux radiating through a specific cross-sectional area encompassed by the contacts connecting pads 18 and 20 to MR sensor 36, while the polarity of the inductive pick-up signal is referenced by the direction of the induced current within contacts 26 and 28 surrounding the specific cross-sectional area.

Contacts 26 and 28 and MR sensor 36, when connected to pads 18 and 20, provide a current contact path in a form of a figure-eight configuration. Bias current, provided by an external current source, begins in pad 18 and travels down contact portion 26a, 26b, and 26c, through MR sensor 36, and returns via contact portion 28c, 28b, and 28a until it returns to pad 20. The current path in Figure 2, represented by arrows, can signify either the bias current or an inductive current induced from disc 35. As can be seen in Figure 2, the figure-eight loop configuration outlines a first loop which encompasses cross-sectional area 38 and a second loop which encompasses cross-sectional area 40.

Since the induced current surrounding cross-sectional area 38 is opposite in polarity as compared to the induced current surrounding cross-sectional area 40, the inductive pick-up voltage signal can be substantially cancelled if the magnetic flux radiating through cross-sectional area 38 times the area of cross-section area 38 during a specific time interval is equal in magnitude as the magnetic flux radiating through cross-sectional area 40 times the area of cross-sectional area 40 during the same time interval.

During a high-performance read application, disc 35 (shown in Figure 1) will be positioned directly under MR sensor 36. Magnetic flux will radiate upward from the magnetic storage medium and produce a desired MR signal. The magnetic flux will also produce an inductive pickup signal. However, since the current path in contacts 26 and 28 form a figure-eight configuration, this inductive signal will be substantially cancelled. Because the planes of the conductors 26 and 28 are substantially perpendicular to the plane of the disc, and parallel to the upward direction of the magnet flux, the inductive pickup signal in cross-sectional area 38 will be substantially equal in magnitude and opposite in polarity as the inductive pickup signal in cross-sectional area 40. With the inductive pickup signal cancelled, the head configuration will be able to read the MR signal radiating from the magnetic storage medium by modulating the resistivity of MR sensor 36 without interference from inductive noise.

Figure 3 is an exploded perspective view of disc drive head 12 which includes rear surface 14, rail 16, pads 18 and 20, contacts 26 and 28, and recess area 34.

Figure 3 illustrates the different metalization layers forming contacts 26 and 28. Metalization layers are placed one on top of another, separated by insulators, to fabricate head 12. As shown in Figure 3, contact portions 28a, 28b, and 28c of contact 28 and contact portion 26c of contact 26 are positioned on a first etch metalization layer and contact portions 26a and 26b are positioned on a second etch metalization layer. The plurality of etch metalization layers is necessary to form the crossover figure-eight configuration of electrical contacts 26 and 28 without shorting out the loops. The relative sizes of the two loops of the figure-eight configuration can be scaled to compensate for decreasing flux distal from disc 35 (shown in Figure 1).

Figure 4 is a greatly enlarged elevational view of the left head portion shown in Figure 1. Head 12 includes rear surface 14, rail 16, pads 18 and 20, contacts 26 and 28 having contact portions 26a, 26b, 26c, 28a, 28b, and 28c respectively, and MR sensor gap 42. MR sensor 36, which is normally positioned within MR sensor gap 42, has been removed from this drawing for purposes of clarity.

During a high-performance read application wherein disc 35 (shown in Figure 1) is located directly beneath rail 16 and having a large relative head disc velocity, MR sensor 36 located within gap 42 will have a changing resistivity due to the magnetic flux radiating from disc 35. Inductive pickup signals will also be detected by MR head 12. However, these undesired inductive pickup signals will be canceled due to the figure-eight configuration of contacts 26 and 28. The figure-eight contact configuration will produce an inductive pickup signal in cross-sectional area 40 (shown in Figure 2) which is equal in magnitude and opposite in polarity as to an inductive pickup signal induced in cross-sectional area 38 (shown in Figure 2) during a specific time interval. Therefore, any inductive pickup signal formed due to the magnetic field radiating from disc 35 will be substantially cancelled. Thus, MR sensor 36 can get an accurate read of the data from disc 35 without substantial peak shifting due to inductive pickup signals.

Figure 5 is a diagrammatic view of an alternative embodiment of the present invention. The diagrammatic view shown in Figure 5 is similar to the diagrammatic view shown in Figure 2. However, the diagrammatic view in Figure 5 includes three cross-sectional areas formed by contacts 26 and 28, rather than only two cross-sectional areas. These three cross-sectional areas are fabricated by having contacts 26 and 28 formed with two cross-overs, rather than only one. Figure 5 illustrates that a plurality of cross-sectional areas similar to cross-sectional areas 38, 40 and 44 can be utilized for inductive pickup signal cancellation, rather than the use of only two areas. The inductive pickup signal will be cancelled if the magnetic field times the cross-sectional area in all areas surrounded by a contact path having a clockwise induced current path is equal to the magnetic flux times the cross-sectional area in all areas surrounded by a contact path having a counterclockwise induced current direction. Thus, the inductive pick-up signal induced in the areas surrounded by a clockwise induced current path will be equal in magnitude and opposite in polarity as the inductive pickup signal induced in the areas surrounded by a counterclockwise induced current path. Therefore, any contact routing scheme having a minimum of two areas surrounded by the contact path can be utilized to minimize the inductive pickup signal.

Figure 6 is a greatly enlarged elevational view of the head portion of the alternative embodiment shown in Figure 5. Disk drive head 12 includes rear surface 14, rail 16, pads 18 and 20, contacts 26 and 28, recessed area 34, and gap 42. During a high-performance read application, disc 35 will be positioned immediately below head 12. MR sensor 36 located within gap 42 will directly read the magnetic field from the magnetic storage medium through use of the changing resistivity of MR sensor 36. The inductive signal induced during the read operation will be substantially canceled due to the contact routing scheme of contacts 26 and 28. Therefore, MR sensor 36 will not transducer an inductive signal which is out of phase with the desired MR signal causing errors by peak shifting away from the desired information channel.

Figures 7 and 8 are diagrammatic views of second and third alternative embodiments of the present invention. The diagrams in Figures 7 and 8 are similar to the diagram in Figure 2. However, the diagrammatic view in Figure 7 shows the crossover portion of contact 26 directly beneath the crossover portion of contact 28, while the diagrammatic view in Figure 8 shows the crossover portion of contact 28 crossing over the crossover portion of contact 26 while contacts 26 and 28 are perpendicular to one another, forming substantially an "X" configuration.

Figures 9 and 10 are a diagrammatic view and a side elevational view of a fourth alternative embodiment of the present invention, respectively. Rather than having a crossover section of contacts 26 and 28 and a plurality of cross-sectional areas, the embodiment in Figure 9 has an overlap portion separated by insulating layer 50 and only one cross-sectional area 38. For illustrative purposes, contact portions 26b and 28b are shown slightly offset from one another. However, in a preferred embodiment, contact portions 26b and 28b are directly overlapping. As shown in Figure 9, contact portions 26b and 28b overlap for a substantial distance between pads 18 and 20 and cross-sectional area 38 and are separated by insulating layer 50. This substantial overlap of contact portions 26b and 28b dictates that cross-sectional area 38 encompassed by contact portions 26c and 28c and MR sensor 36 is relatively small. As earlier discussed, the inductive pickup signal is equal to the change in an applied field, such as magnetic flux, times a given area divided by a change in time (i.e., a time rate of change of the applied field). The magnitude of the inductive pickup signal is directly proportional to cross-sectional area 38 encompassed by contact portions 26c and 28c and MR sensor 36. Therefore, since cross-sectional area 38 is very small in this embodiment due to the overlap of contact portions 26b and 28b, the inductive pickup signal produced during the detection of an MR signal is minimized.

Figure 10 is a side elevational view of the forth embodiment shown in Figure 9 as seen from left to right and shows the different metalization layers which are utilized to properly form contacts 26 and 28. As shown in Figure 10, contact portions 26a, 26b, and 26c are all located on first metalization layer 46 while contact portions 28a and 28c are located on first metalization layer 46 and contact portion 28b is located on second metalization layer 48. The two metalization layers are separated by insulating layer 50, which prevents an electrical short between the two metalization layers. The plurality of metalization layers allow contacts 26 and 28 to be properly formed. Without the plurality of metalization layers, contacts 26 and 28 could not overlap one another, nor could they cross over one another.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail.

Claims

1. An electrical contact configuration for connecting a magnetoresistive sensor (36) for sensing magnetic flux from a storage medium (35) to further circuitry, the contact configuration having first (28) and second (26) electrically conductive paths from said magnetoresistive sensor (36) to the further circuitry, characterised in that the conductive paths (26,28) are arranged such that they reduce the effect of an inductive pick-up signal occurring due to the storage medium (35) on the electrical signal applied to said further circuitry via the electrically conductive paths (26,28) and said magnetoresistive sensor.

2. A contact configuration according to claim 1, wherein a first of said conductive paths (28) overlaps a first portion (26b) of a second of said conductive paths (26) to reduce inductive current of the inductive pick-up signal induced from the storage medium (35) in a single loop formed by the first conductive path (28), a second portion (26c) of the second conductive path (26) and the magnetoresistive sensor (36).

3. A contact configuration according to claim 2, wherein the first and second conductive paths (28,26) define a three-dimensional configuration residing on at least two metalisation layers separated by an insulating layer (50).

4. A contact configuration according to claim 3, wherein the first portion (26b) of the second electrical contact (26) is positioned on the insulating layer (50).

5. A contact configuration according to claim 1, wherein the first (28) and second (26) conductive paths together define a plurality of electrically conductive loops (38,40,44) in a plane substantially perpendicular to the plane of the storage medium (35), the conductive loops (38,40,44) forming cross-over areas between them, and the first (28) and second (26) conductive paths being electrically insulated at the cross-over areas so that current flows from the further circuitry through an input section (18) of the plurality of loops (38,40,44), through the magnetoresistive sensor (36) and returns to the further circuitry via an output section (20) of the plurality of loops (38,40,44).

6. A contact configuration according to claim 5, wherein the plurality of electrically conductive loops (38,40,44) comprises a pair of oppositely orientated loops.

7. A contact configuration according to claim 5 or 6, wherein the loops are arranged such that a first portion of the inductive pick-up signal is induced in a first loop (28) and a second portion of the inductive pick-up signal is induced in a second loop (26), and a first portion of the inductive pick-up signal is substantially equal in magnitude and opposite in polarity to the second portion of the inductive pick-up signal.

8. A contact configuration according to any one of claims 5, 6 or 7, wherein the conductive paths (28,26) define two loops, the loops being so sized and positioned in relation to the magnetoresistive sensor (36) as to reduce the inductive pick-up signal during sensing of the magnetic flux.

9. A contact configuration according to claim 5, wherein the plurality of loops comprises a first loop (40), a second loop (38) and a third loop (44).

10. A contact configuration according to claim 9, wherein a first portion of the inductive pick-up signal induced in the first loop (40), a second portion of the inductive pick-up signal is induced in the second loop (38), and a third portion of the inductive voltage signal is induced in the third loop (44), the second portion of the inductive pickup signal being substantially equal in magnitude and opposite in polarity to a combination of the first

portion and a second portion of the inductive pick-up signal.

11. A contact configuration according to claim 9 or 10, wherein the conductive paths (28,26) define three loops, the loops being so sized and positioned in relation to the magnetoresistive sensor (36) as to reduce the inductive pick-up signal during sensing of the magnetic flux.

12. A contact configuration according to any one of claims 5 to 11, wherein the conductive paths (28,26) define a three-dimensional configuration residing on at least two metalisation layers separated by non-metalisation layers.

13. A contact configuration according to claim 12, wherein a first portion of the conductive paths (28,26) resides on a first metalisation layer and a second portion of the conductive paths (28,26) resides on a second metalisation layer.

14. A contact configuration according to any one of claims 5 to 13, wherein the conductive paths (28,26) define a figure-eight configuration.

15. A contact configuration according to any preceding claim, wherein the conductive paths (28,26) receive a bias current from the external circuitry.

16. A storage medium read head (12) for reading data from a storage medium (35) which includes at least one electrical contact configuration according to any one of claims 1 to 15.

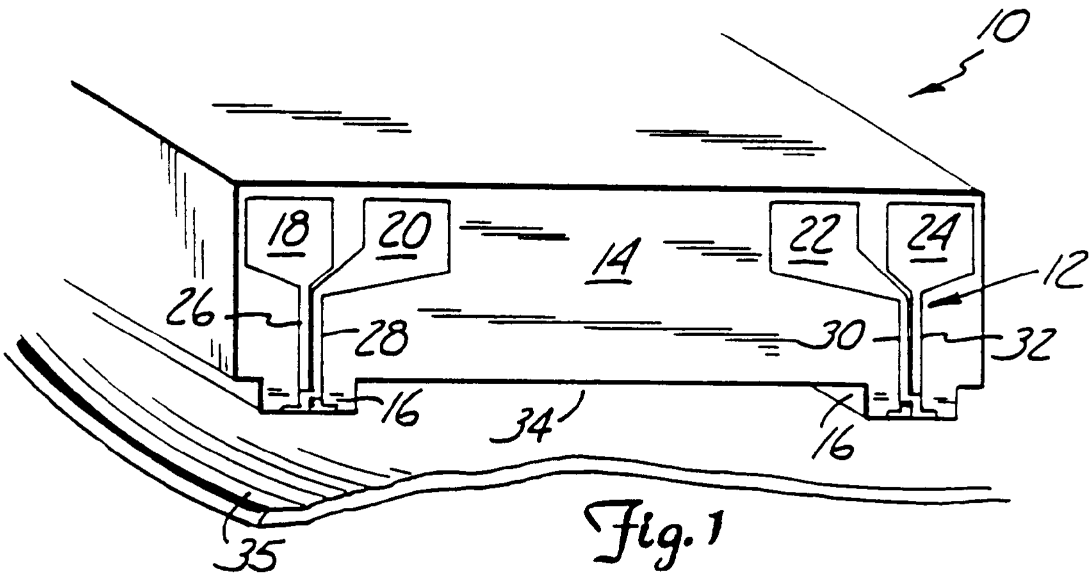
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Fig. 1

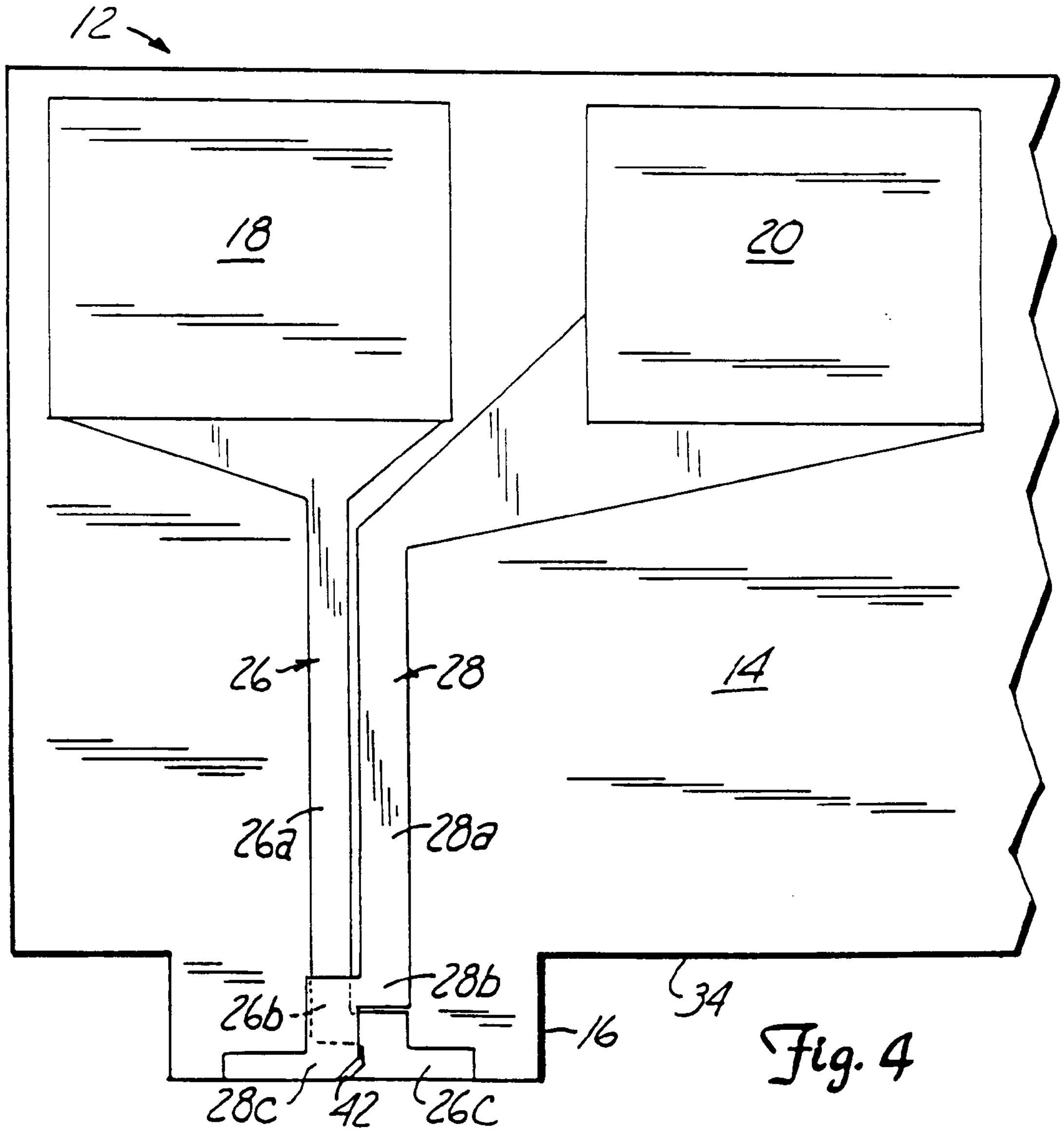
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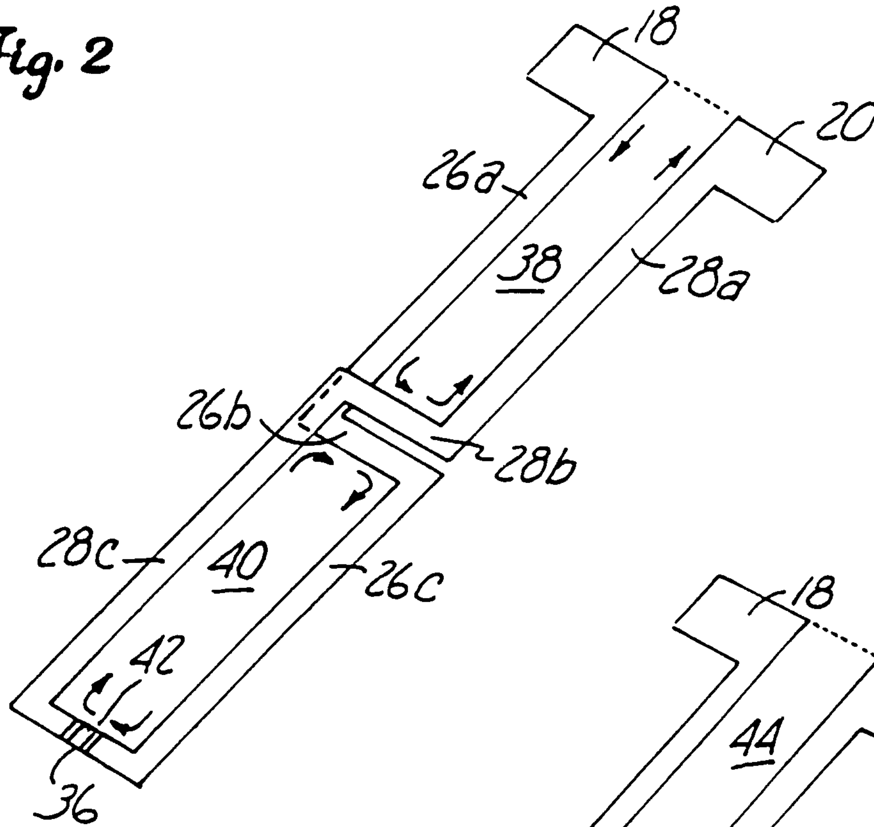
Fig. 4

Fig. 2



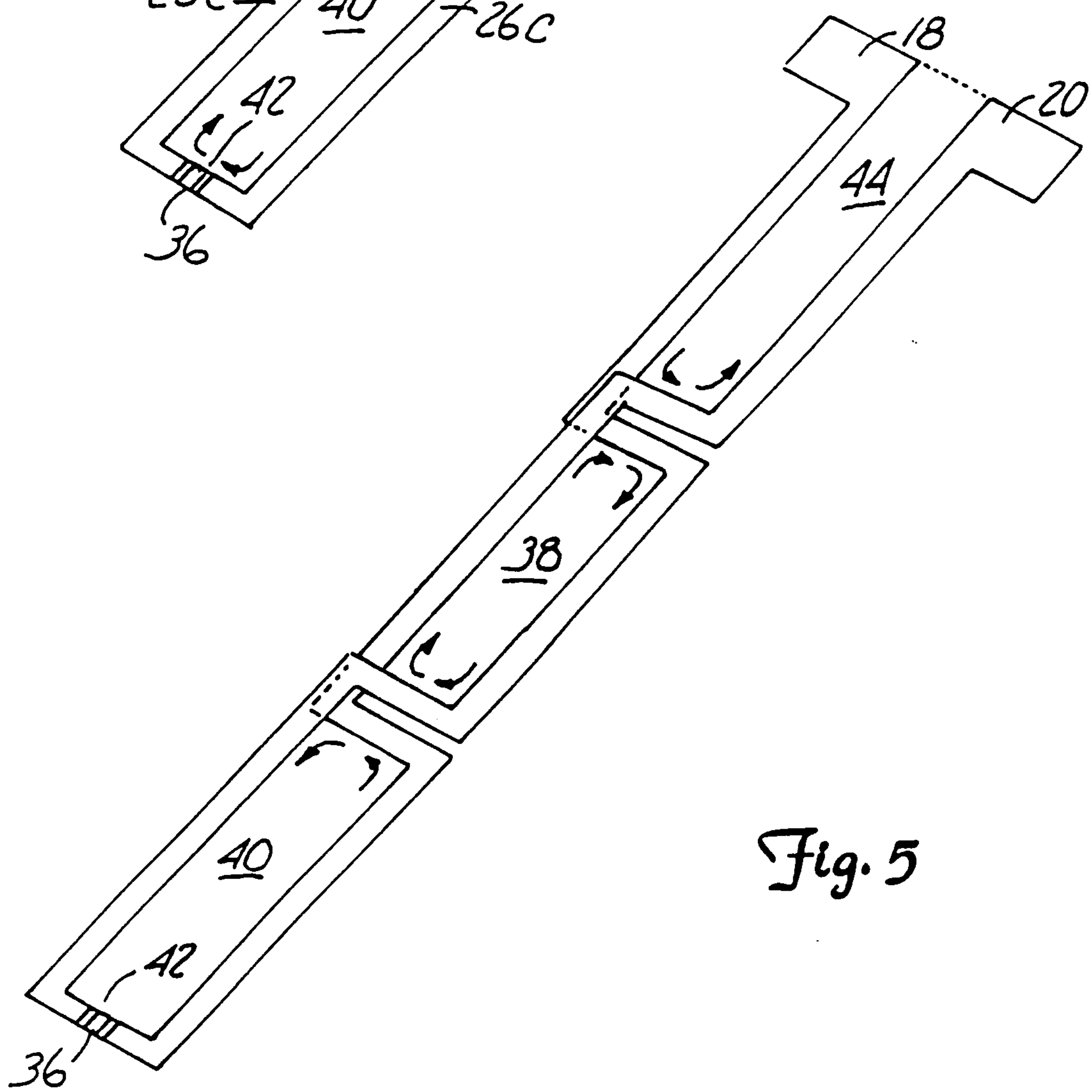


Fig. 5

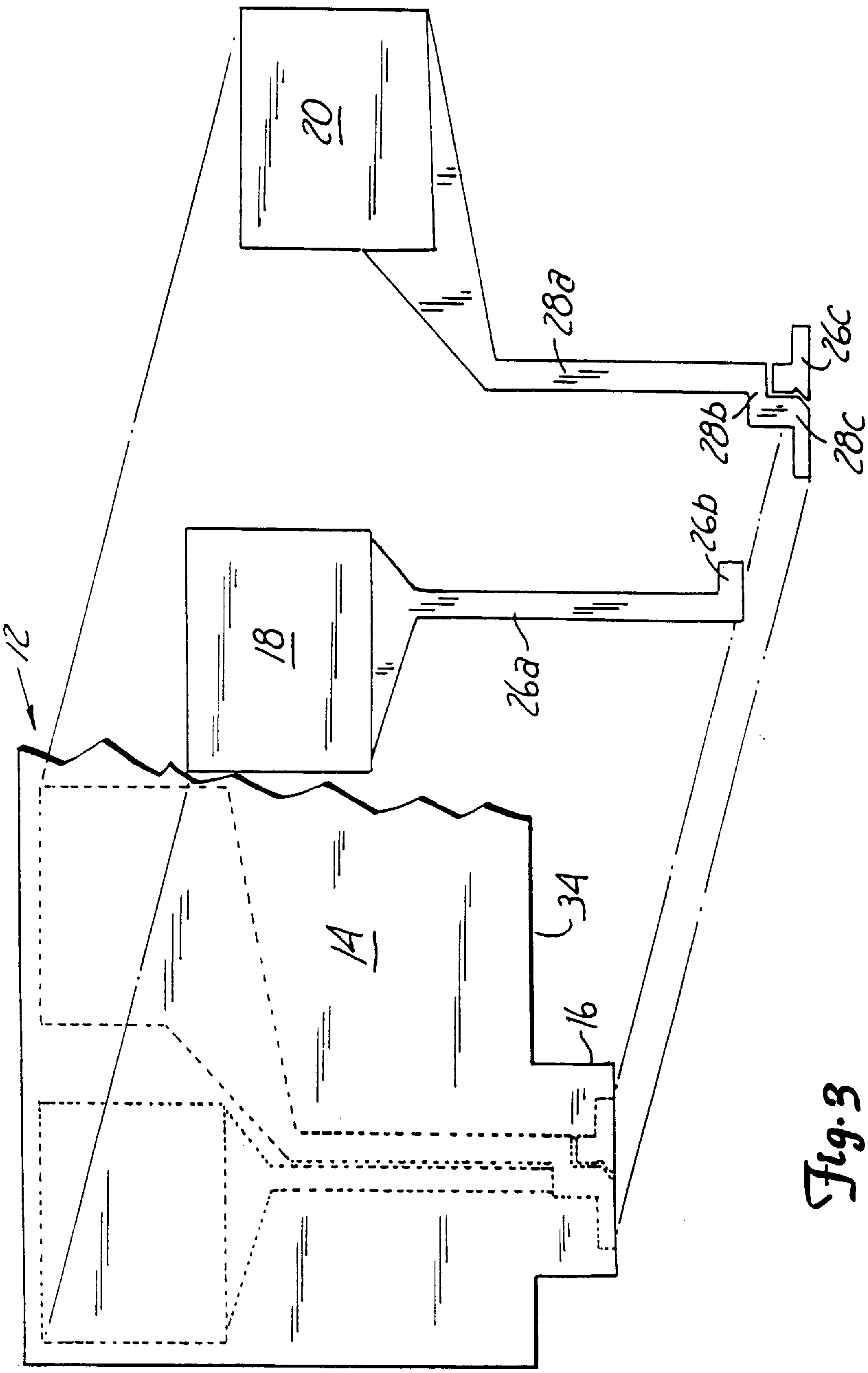


Fig. 3

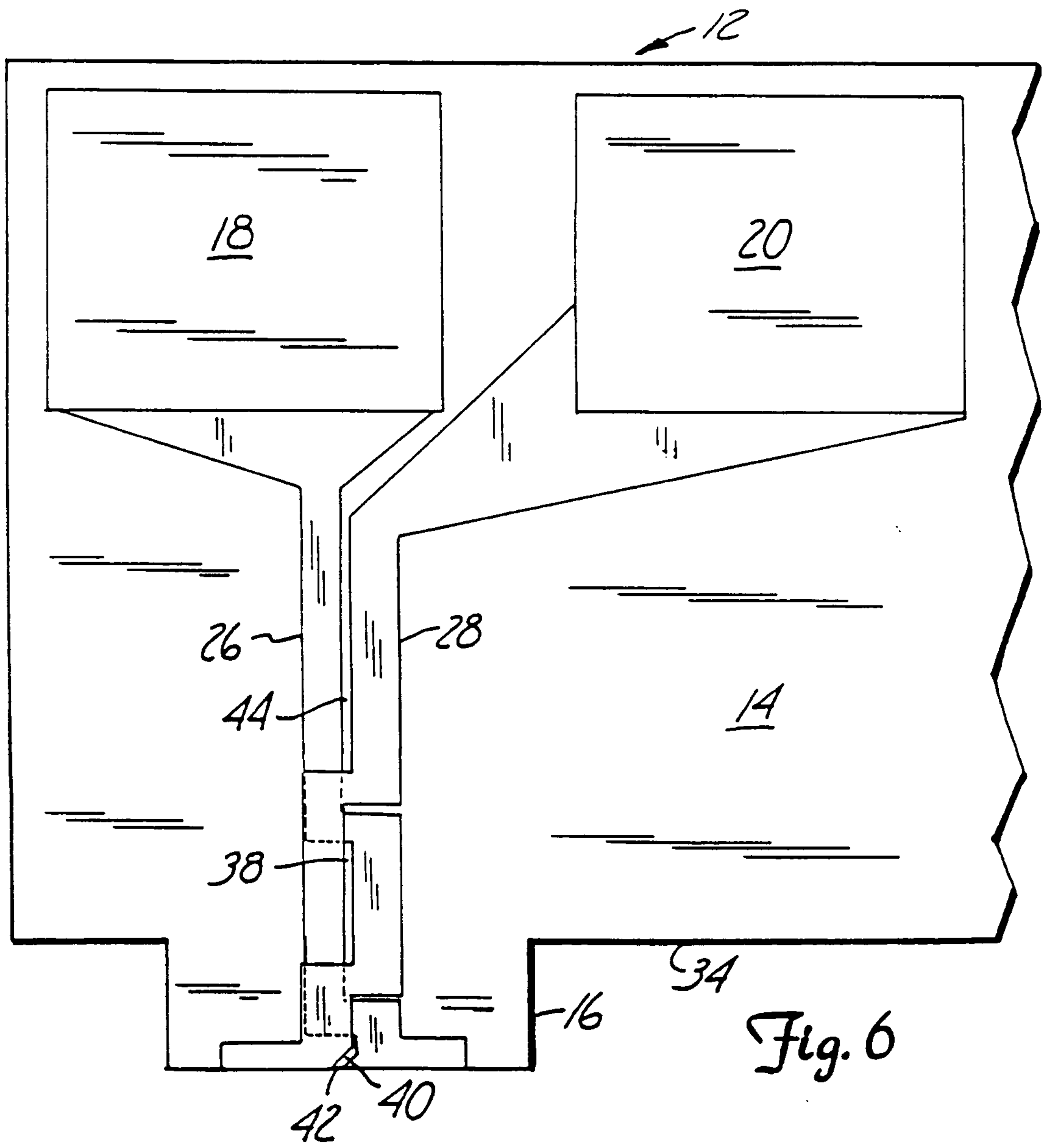
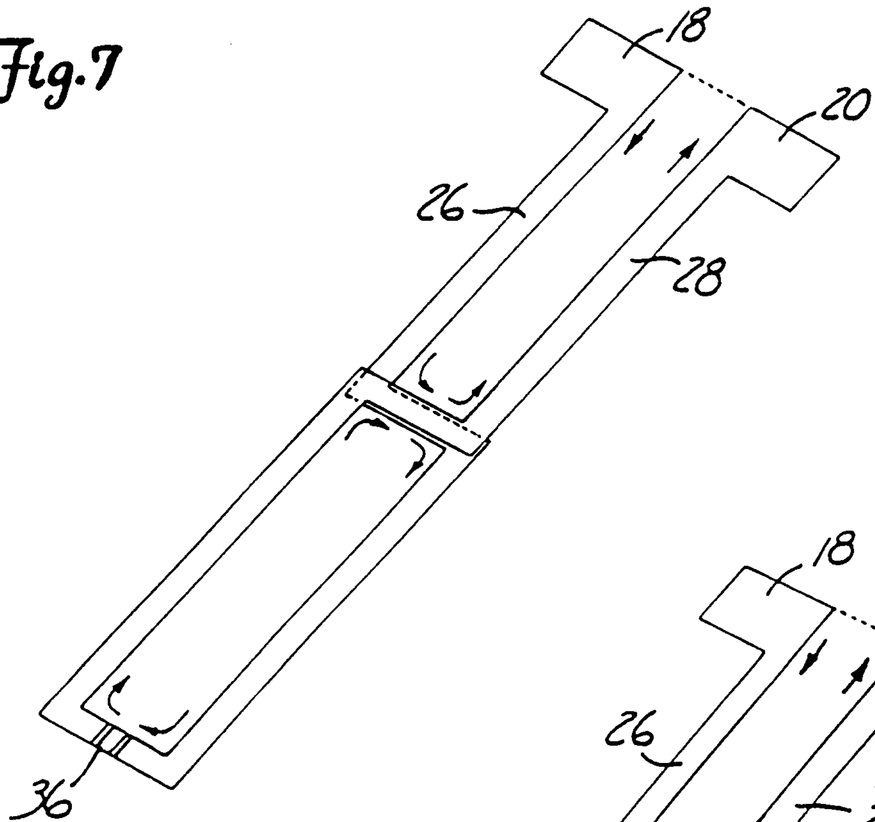


Fig. 6

Fig.7



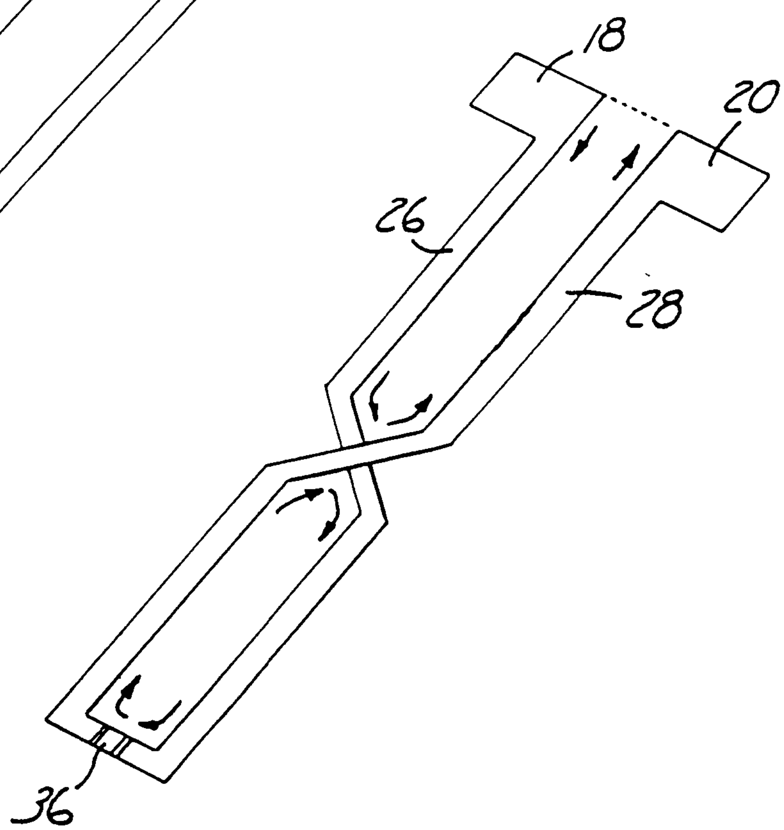


Fig.8

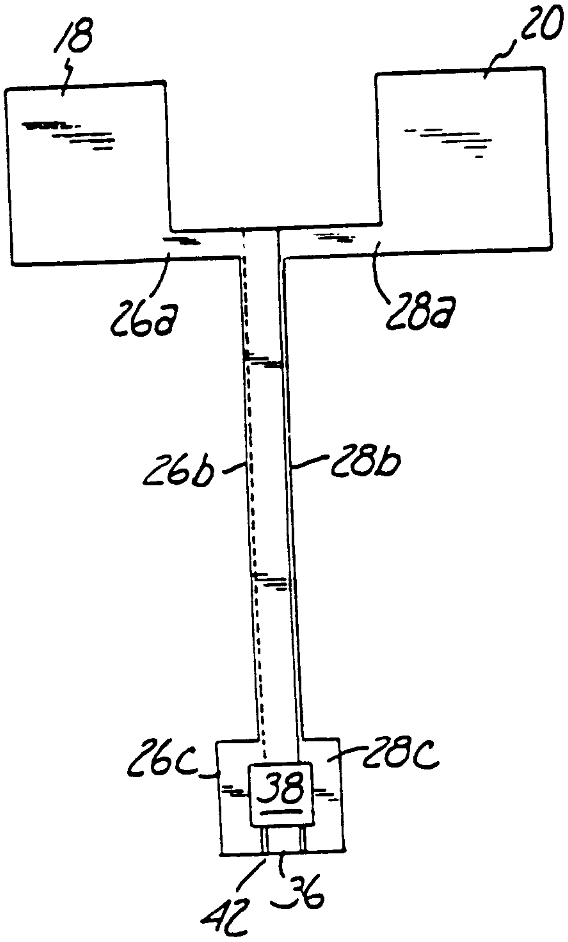


Fig. 9

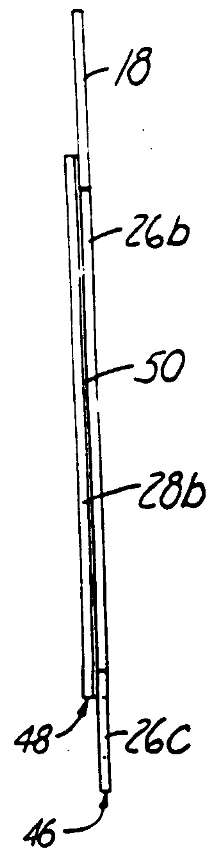


Fig. 10

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 7713

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 12, no. 233 (P-724) 5 July 1988 & JP-A-63 025 820 (SONY CORP.) 3 February 1988 * abstract * ---	1-4	G11B5/39
X Y	PATENT ABSTRACTS OF JAPAN vol. 9, no. 259 (P-397) 17 October 1985 & JP-A-60 109 010 (NIPPON DENSHIN DENWA KOSHA) 14 June 1985 * abstract * ---	1,5-14, 16 15	
Y	US-A-4 713 708 (KROUNBI M.T.) * abstract; figure 2 * ---	15	
X	PATENT ABSTRACTS OF JAPAN vol. 17, no. 505 (P-1611) 10 September 1993 & JP-A-05 128 447 (FUJITSU LTD.) 25 May 1993 * abstract * ---	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 12, no. 233 (P-724) 5 July 1988 & JP-A-63 025 819 (SONY CORP.) 3 February 1988 * abstract * ---	1,5-8, 12-14,16	G11B
X	PATENT ABSTRACTS OF JAPAN vol. 16, no. 123 (P-1330) 27 March 1992 & JP-A-03 290 812 (HITACHI LTD.) 20 December 1991 * abstract * -----	1,16	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	4 January 1995	Deane, E

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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